Comparison of Surface Fluxes Derived from CYGNSS and Simulated by WRF Model : An MJO Case Study

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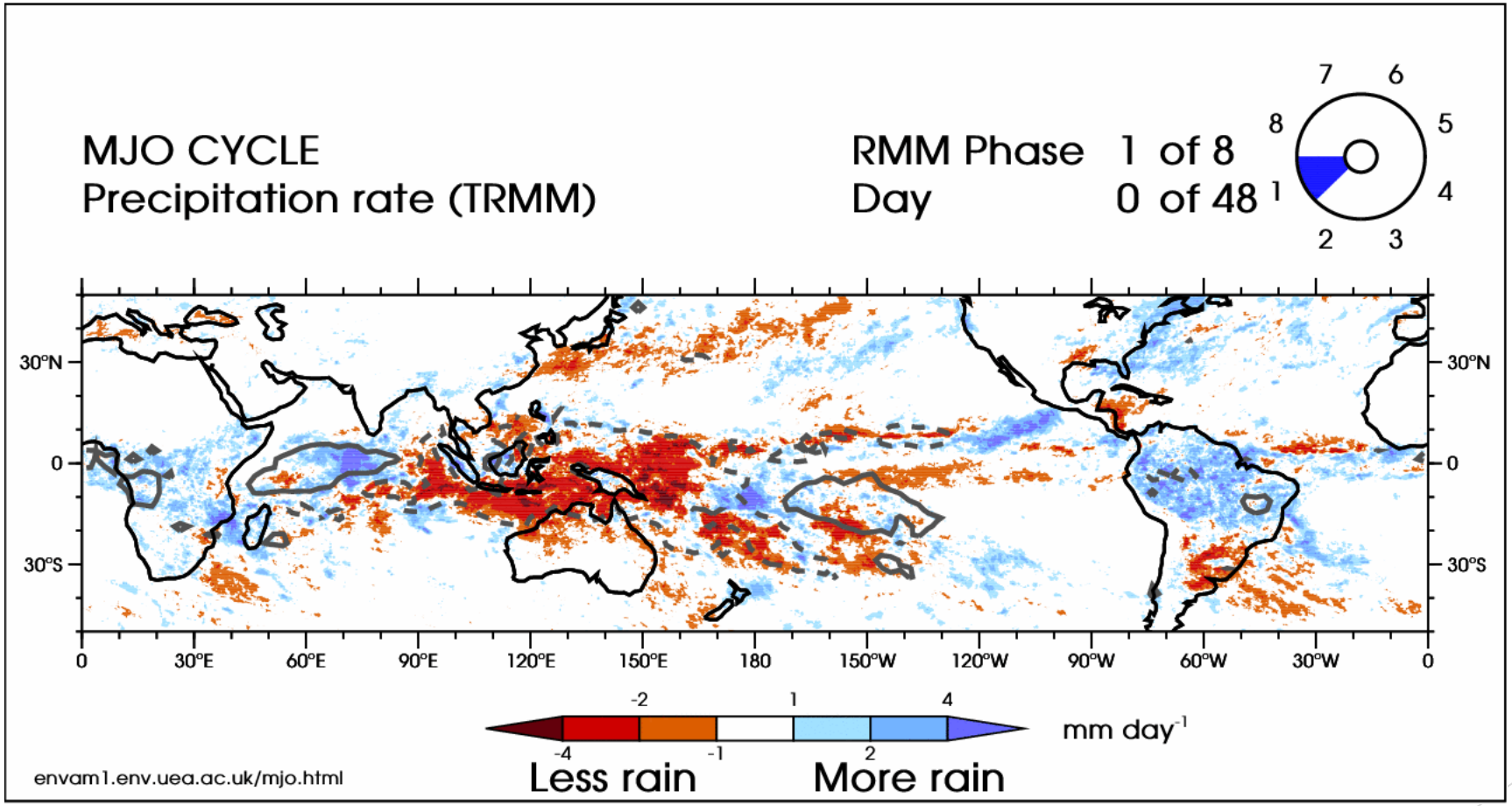
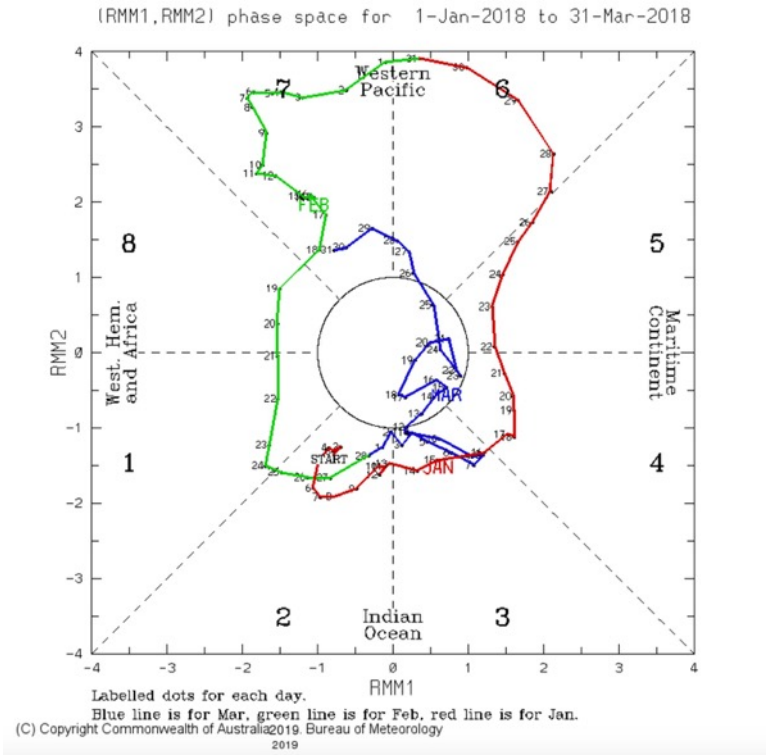
Precipitation Structure of a Madden Julian Oscillation (MJO)



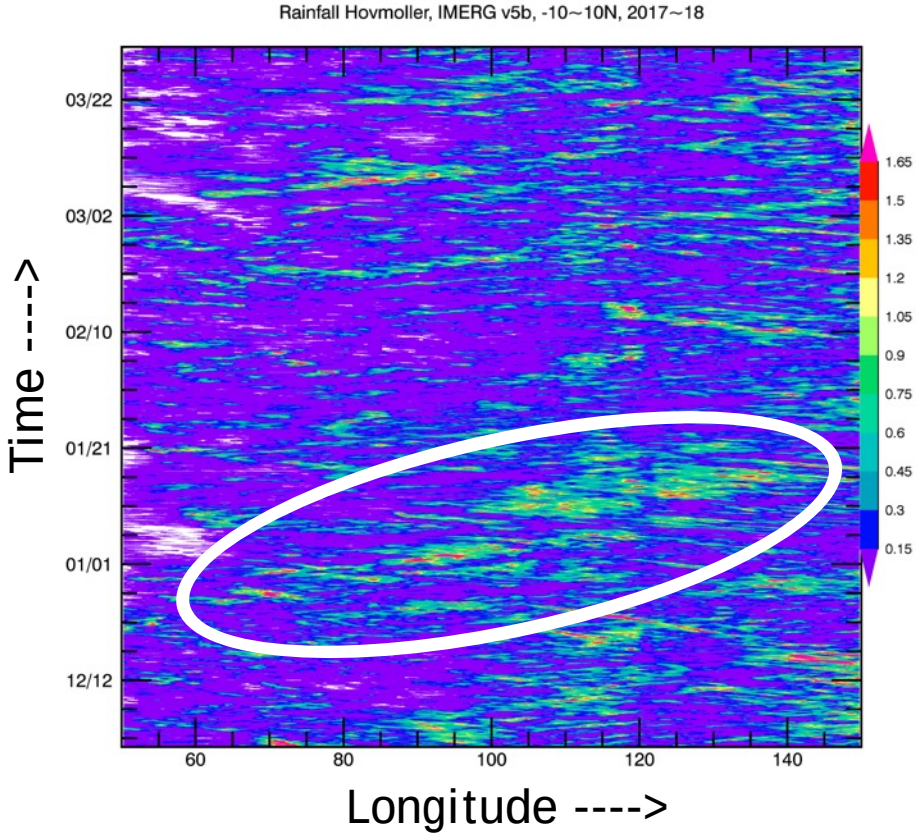
Animation Credit: Professor Adrian Matthews, University of East Anglia, Norwich, UK

2017-2018 MJO events with CYGNSS data

MJO Multivariate Index



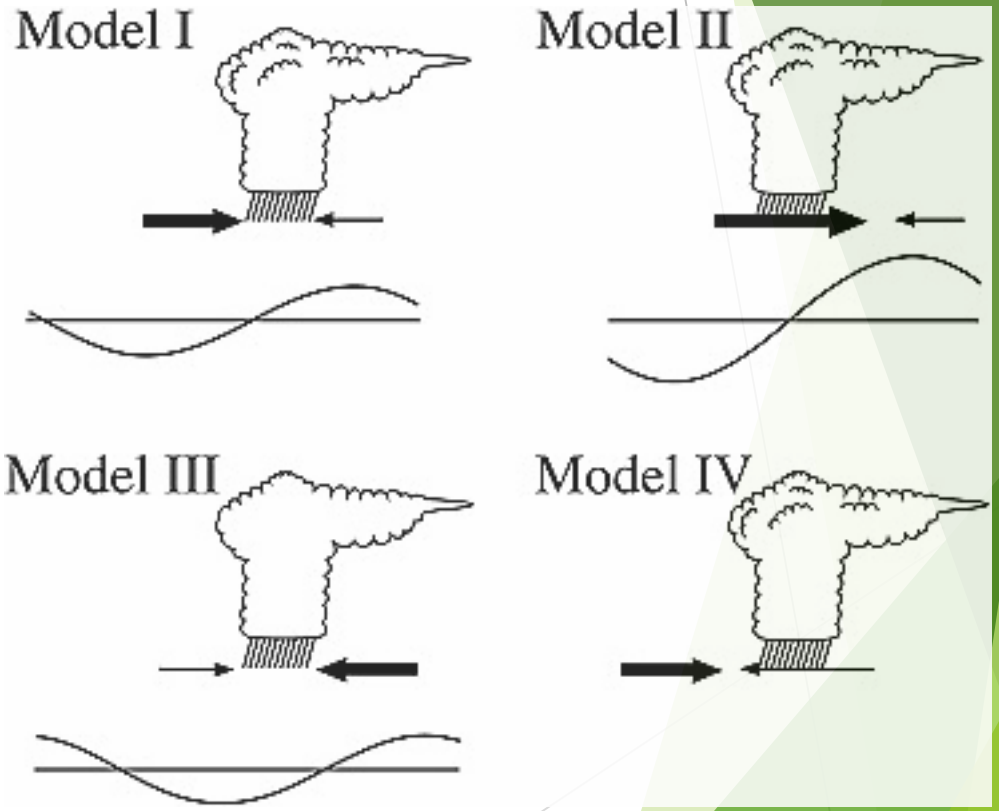
Surface Rainfall Hovmoller Diagram



MJO initiation and propagation mechanisms remain a major challenge

CYGNSS data advantages:

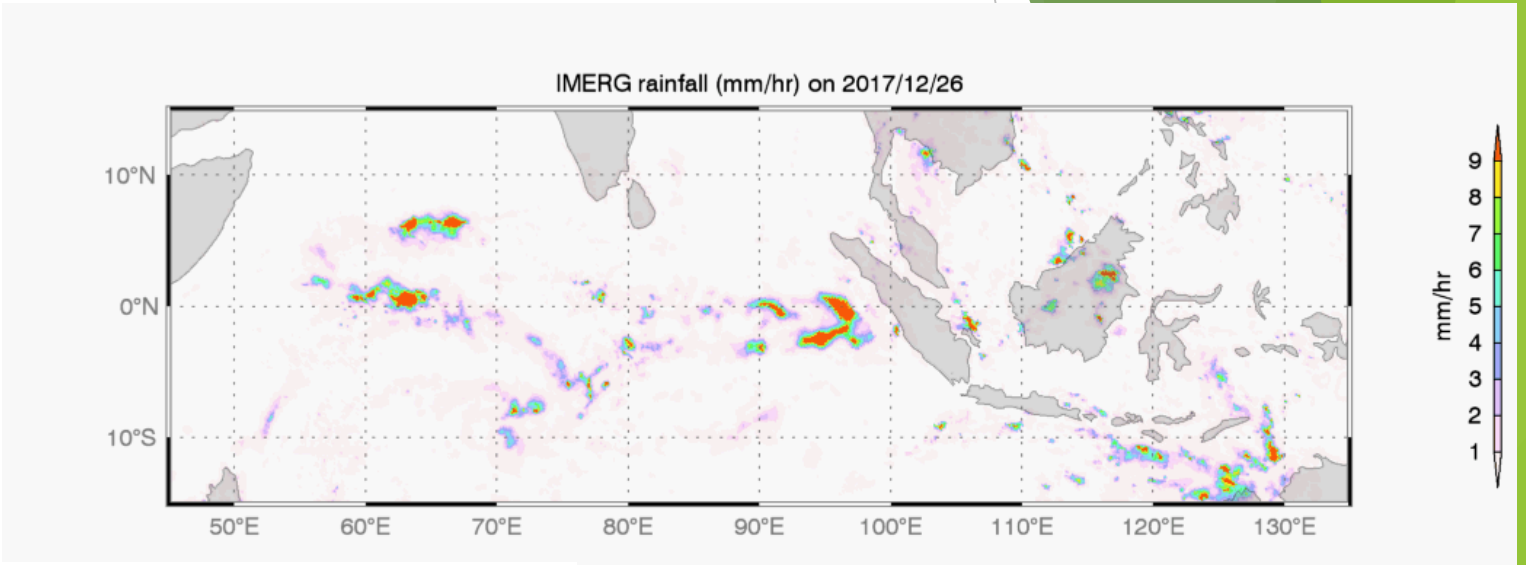
- Can “see” underneath rain;
- High resolution of 25 km can resolve convective systems associated MJO mature phases;

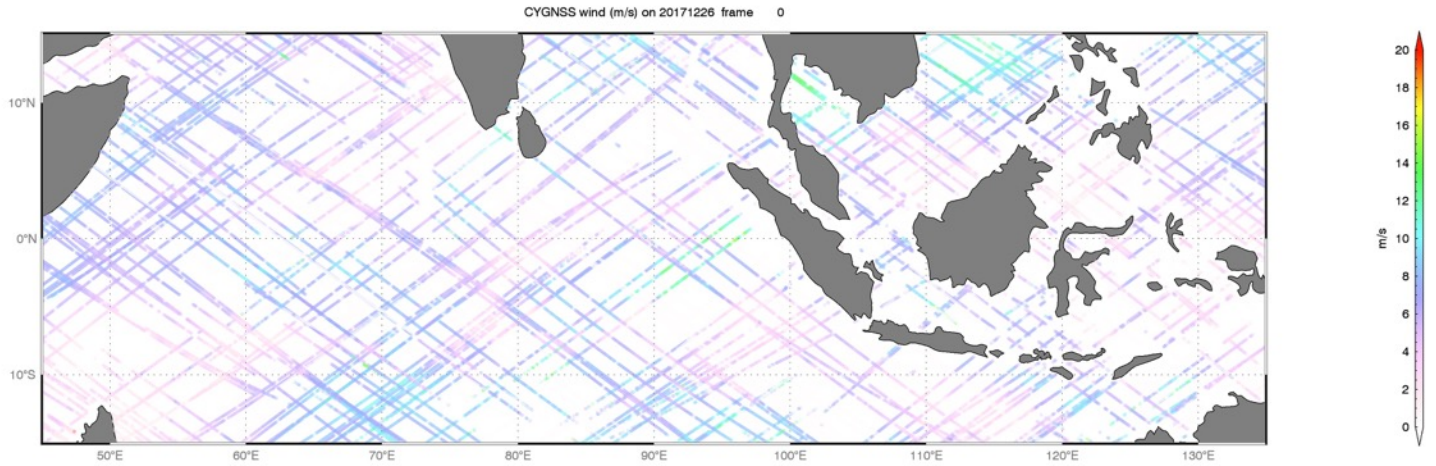


Schematic diagrams of four MJO models describing the phase relationship between its convective centers and surface zonal wind. From Zhang and Anderson, JAS, 2003.

Data Sources (2017 December MJO Case Study)

IMERG surface rainfall
0.1º x 0.1º half-hourly

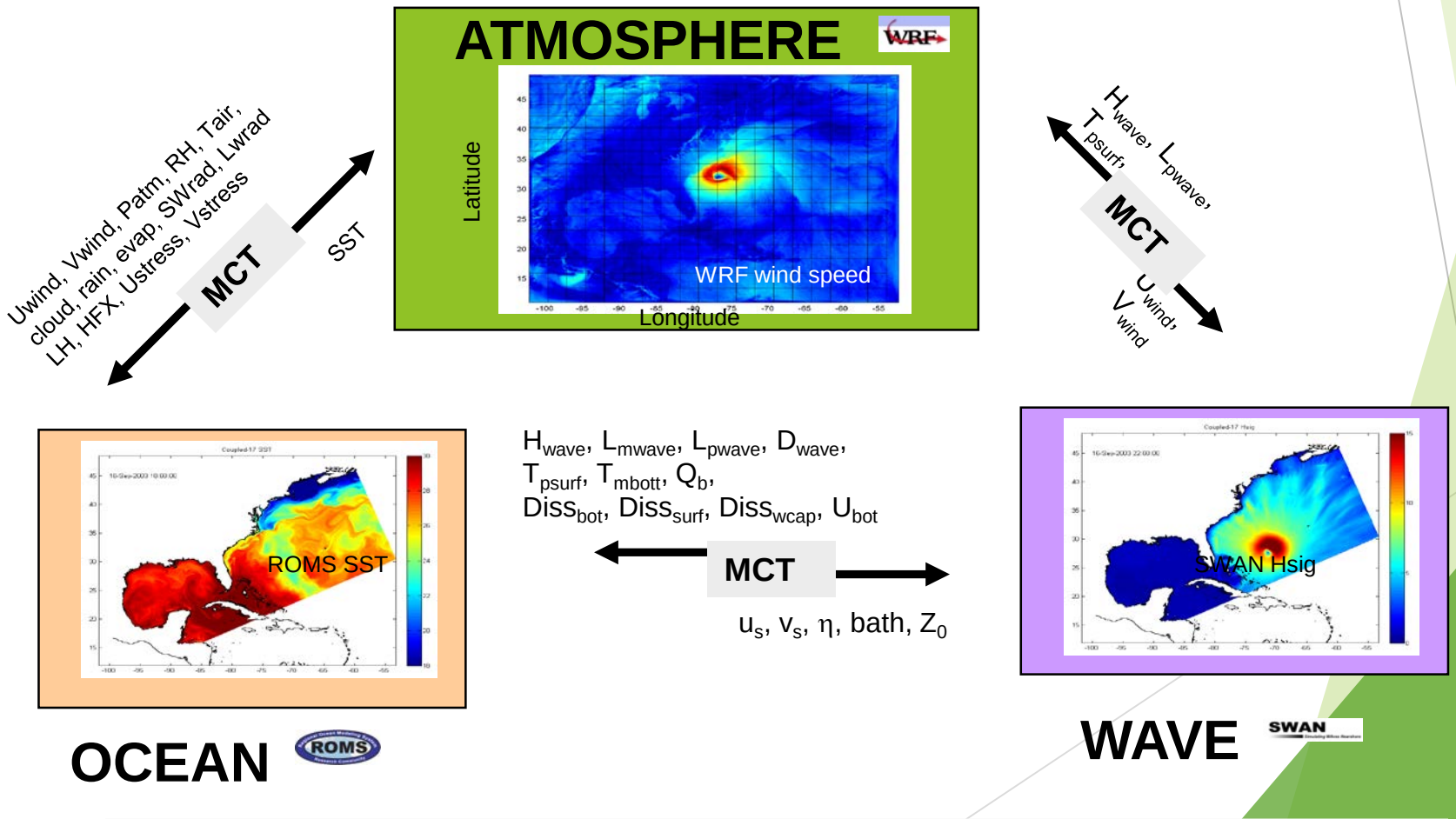




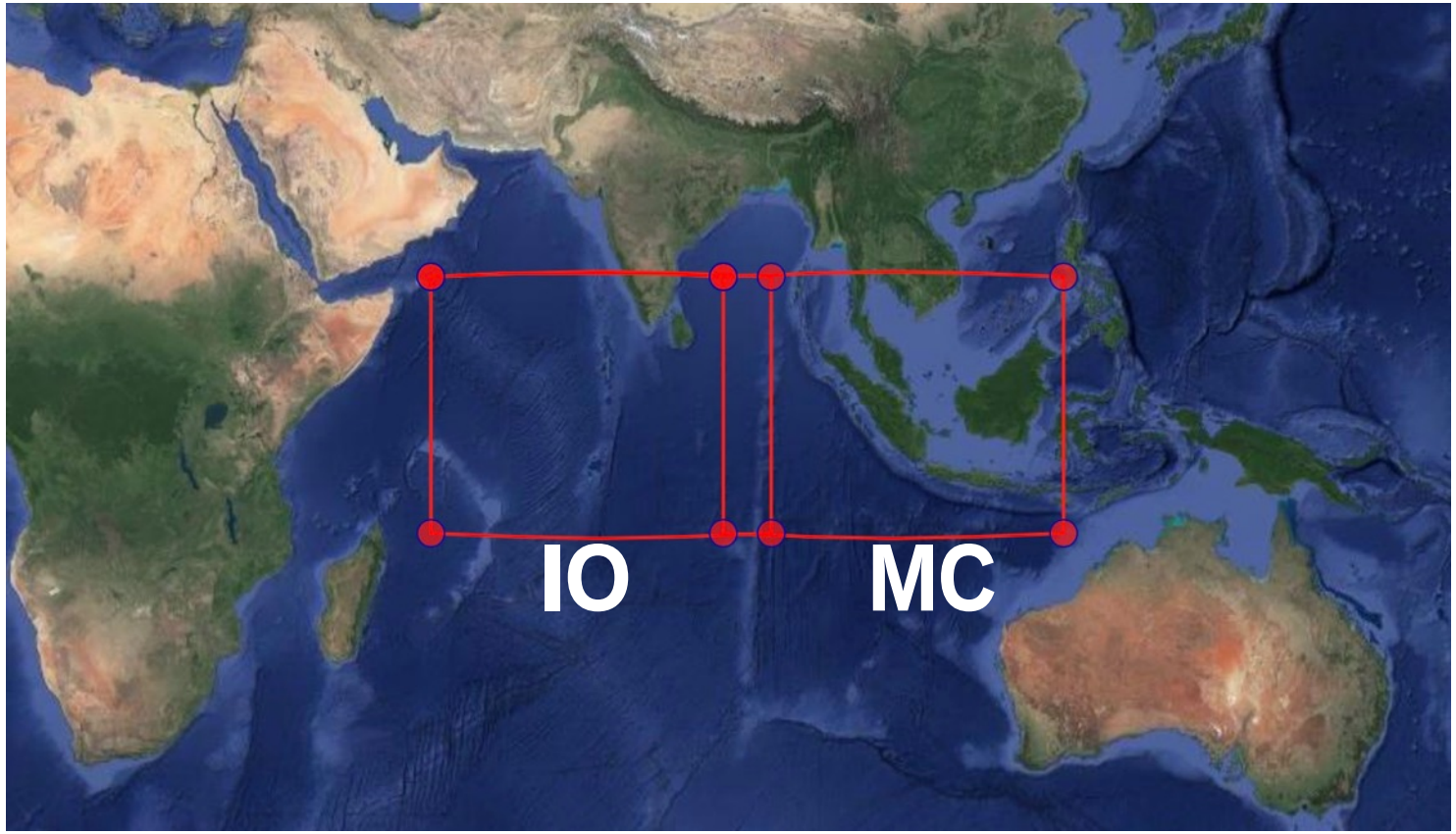
CYGNSS wind retrieval
0.25º one day orbit

Model Descriptions

COAWST: Coupled Ocean-Atmosphere-Wave-Sediment Transport Model
WRF: Weather Research and Forecasting Model
ROMS: Regional Ocean Modeling System
SWAN: Simulating WAve Nearshore model or **Wavewatch III** model

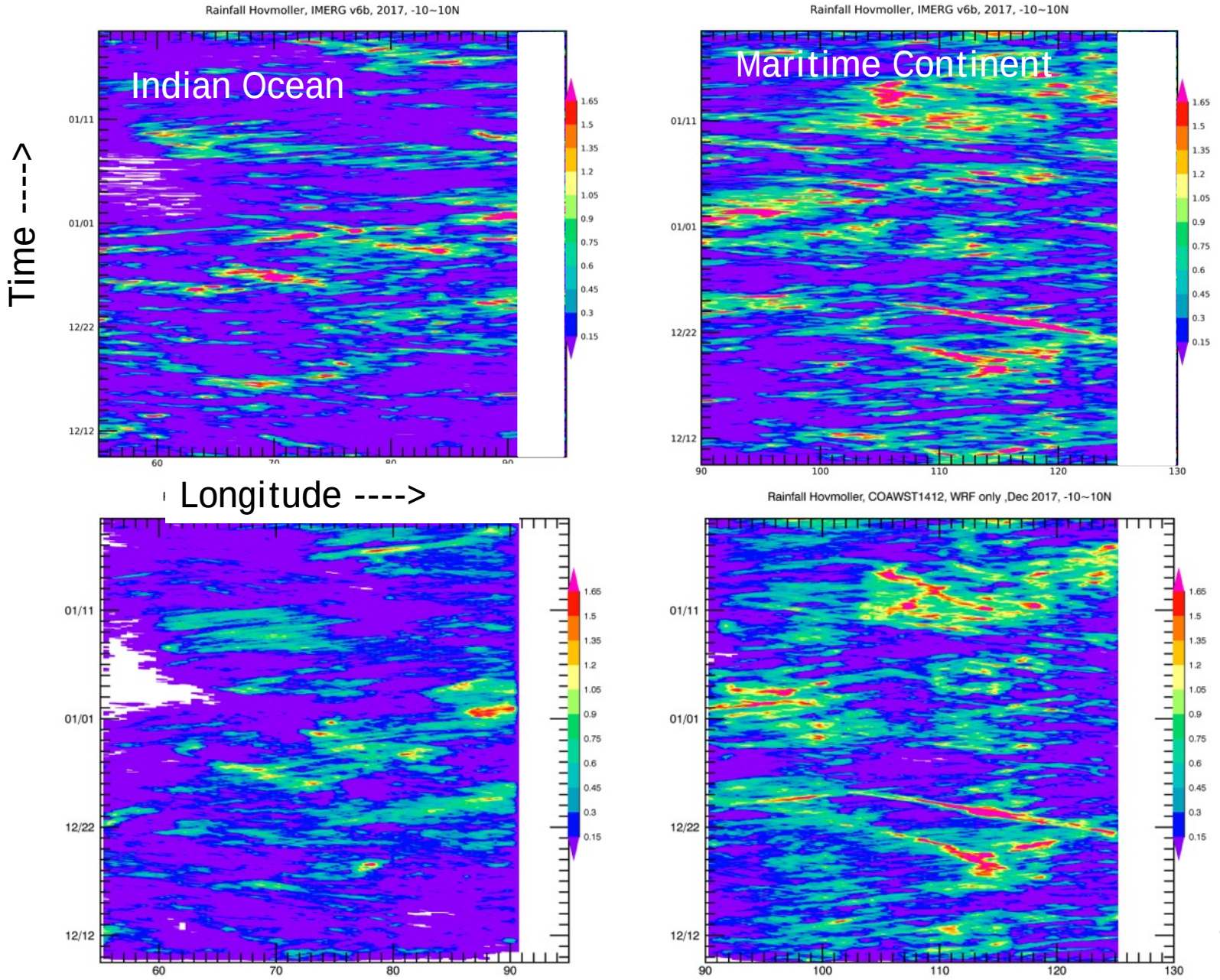


Case Study Design



Two Single Domain Simulations, 4 km resolution, 51 vertical layers. WRF model uses ERA-interim, ROMS uses HYCOM analysis as initial and boundary condition. 40-day simulations starting Dec. 10, 2017.

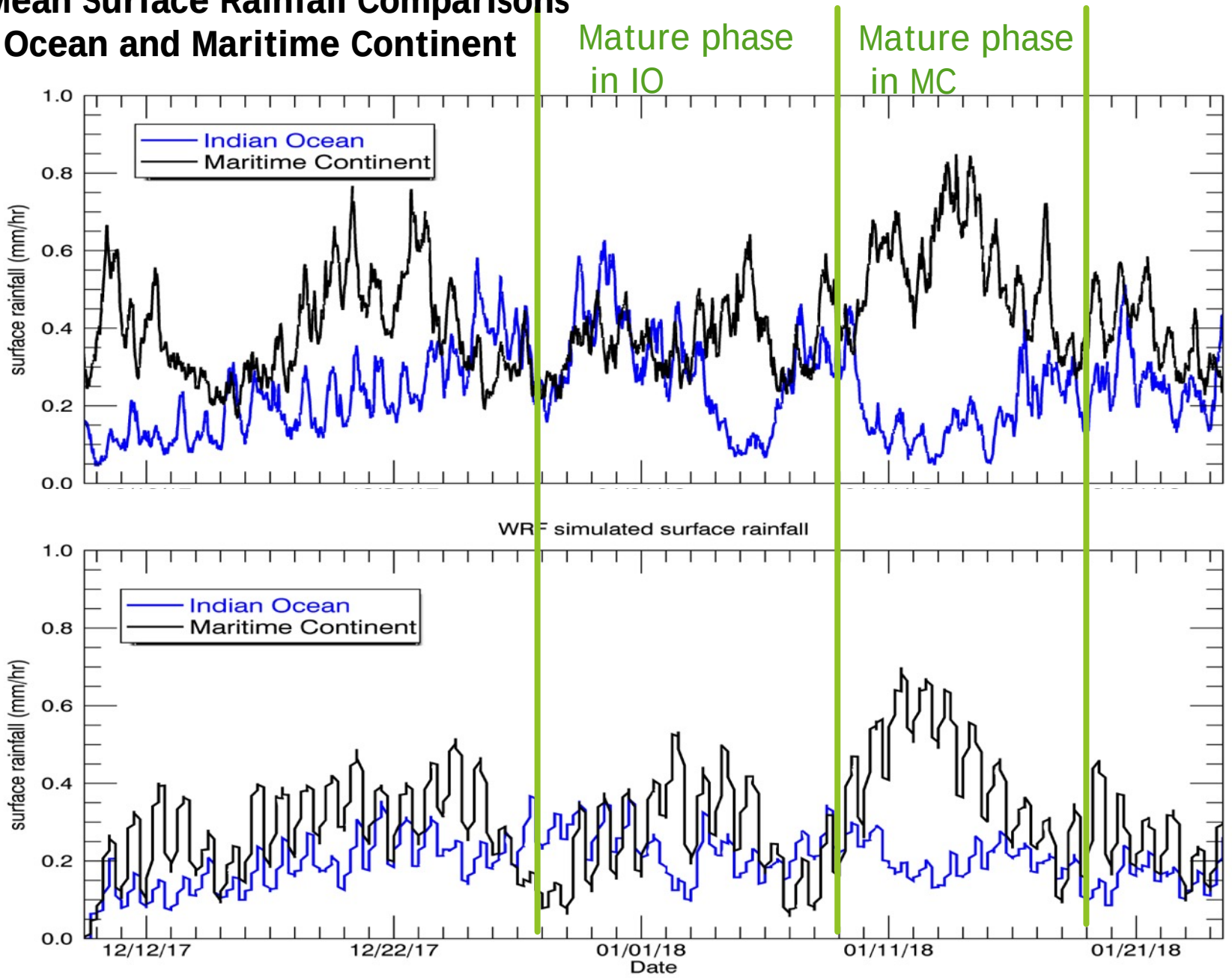
IMER/Model Precipitation Comparisons



IMERG Retrieved Surface Rainfall

WRF Model Simulated Surface Rainfall

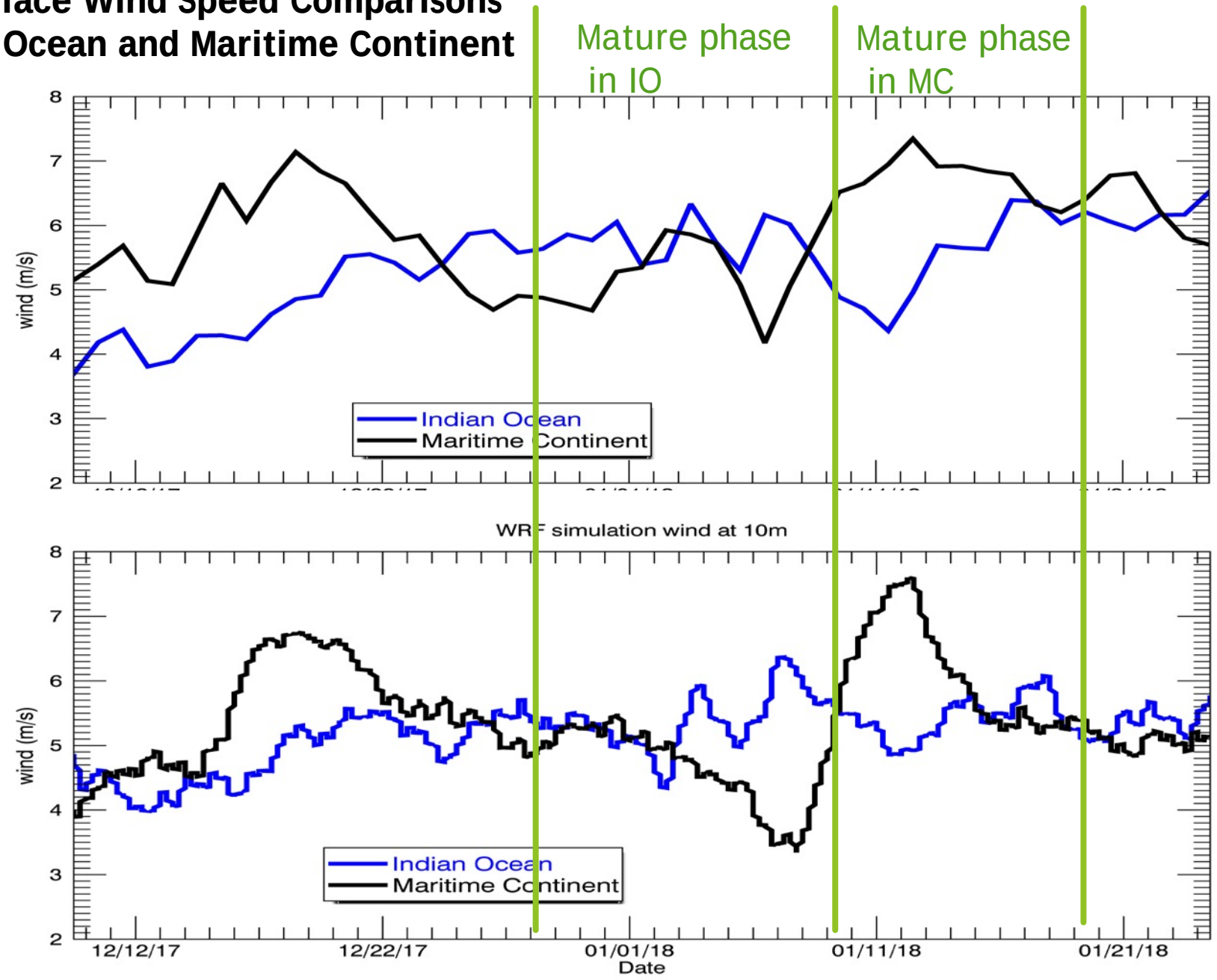
Domain Mean Surface Rainfall Comparisons
In Indian Ocean and Maritime Continent



IMERG

WRF

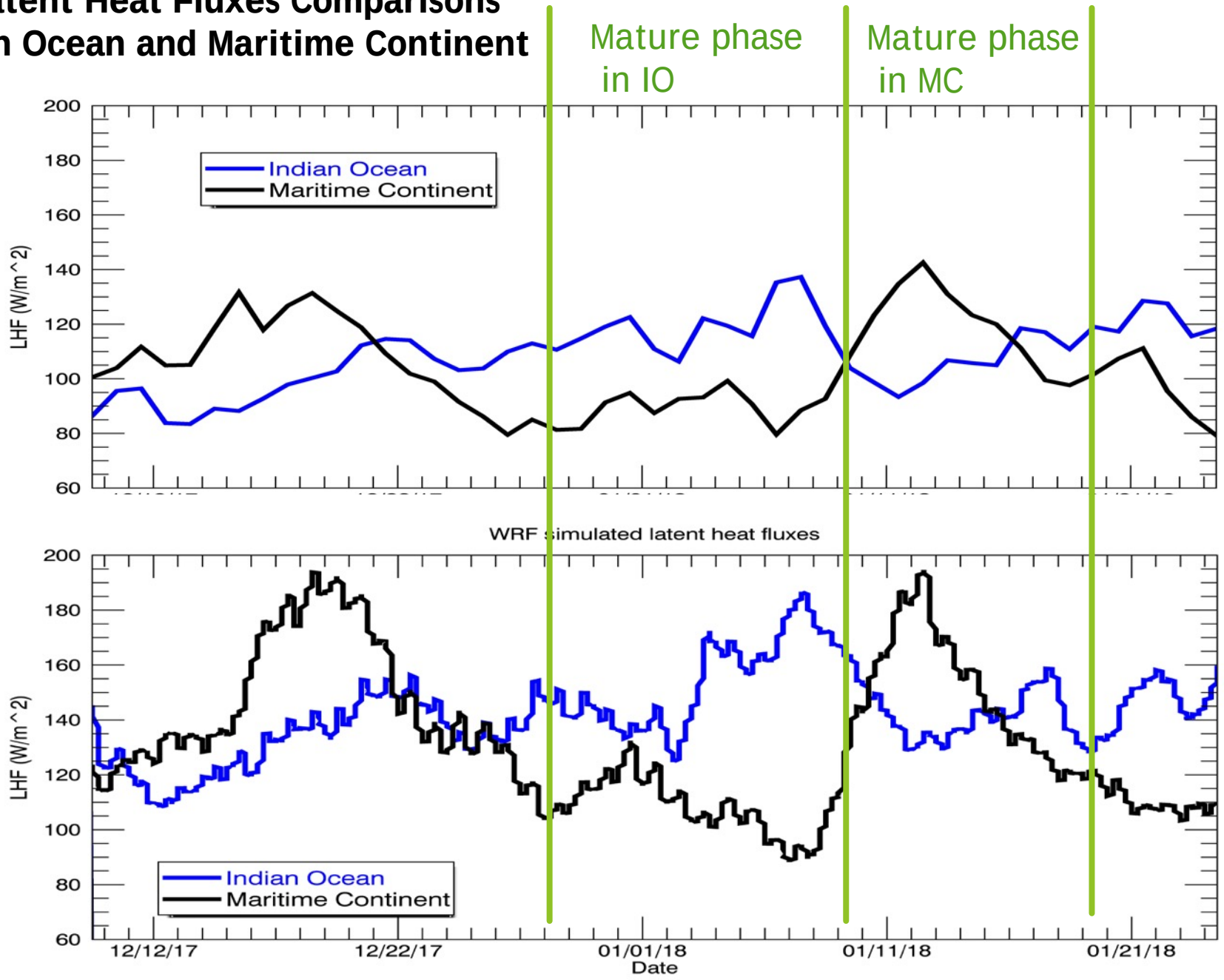
Mean Surface Wind Speed Comparisons
In Indian Ocean and Maritime Continent



CYGNSS

WRF

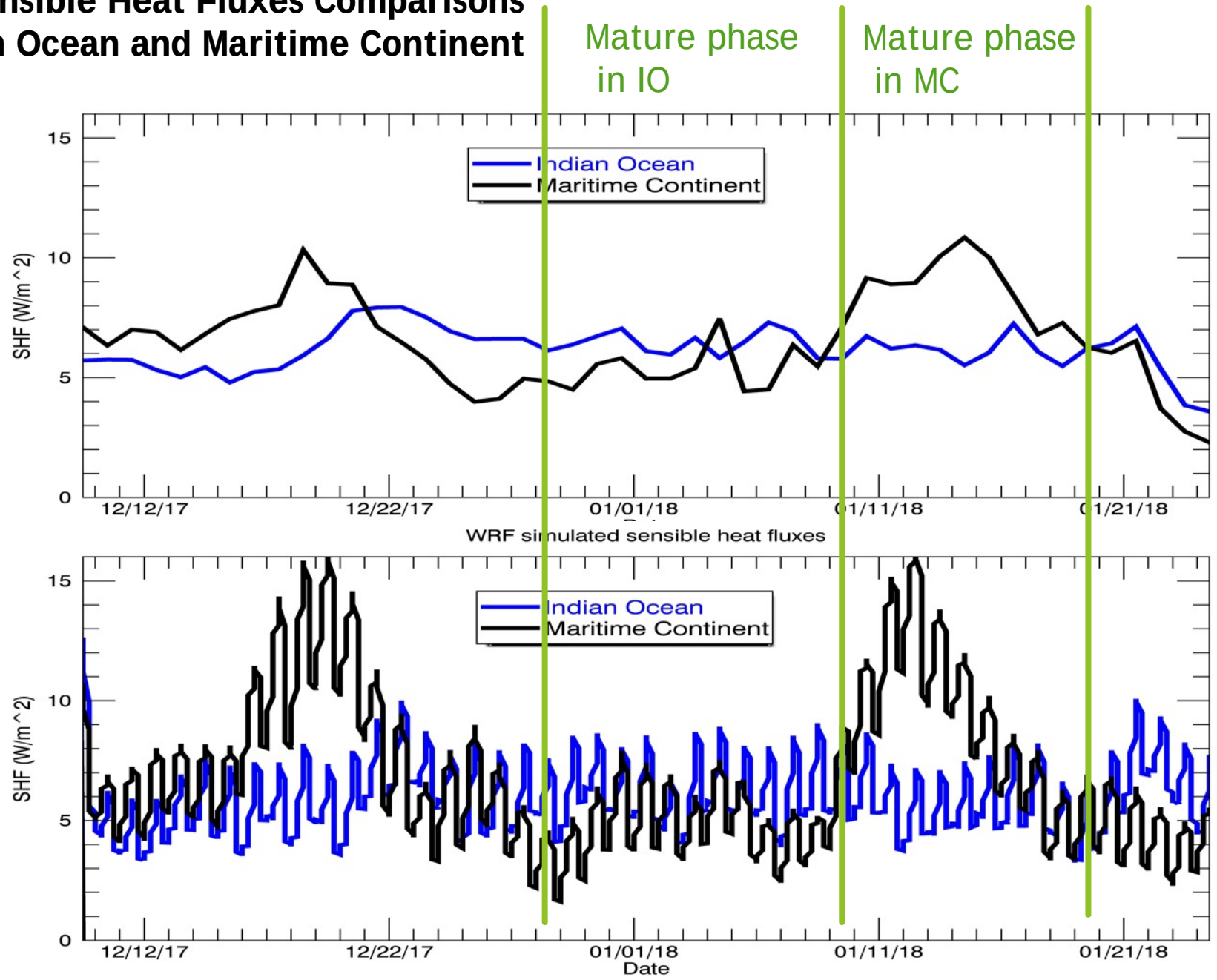
Mean Latent Heat Fluxes Comparisons In Indian Ocean and Maritime Continent



CYGNSS

WRF

Mean Sensible Heat Fluxes Comparisons In Indian Ocean and Maritime Continent

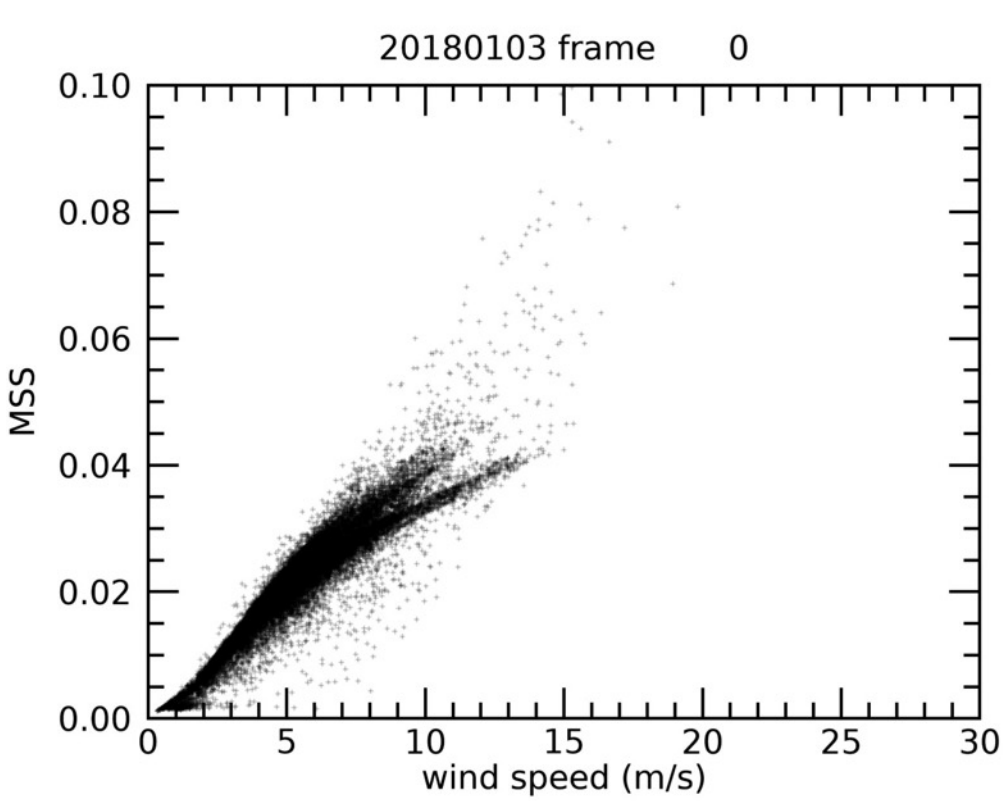


CYGNSS

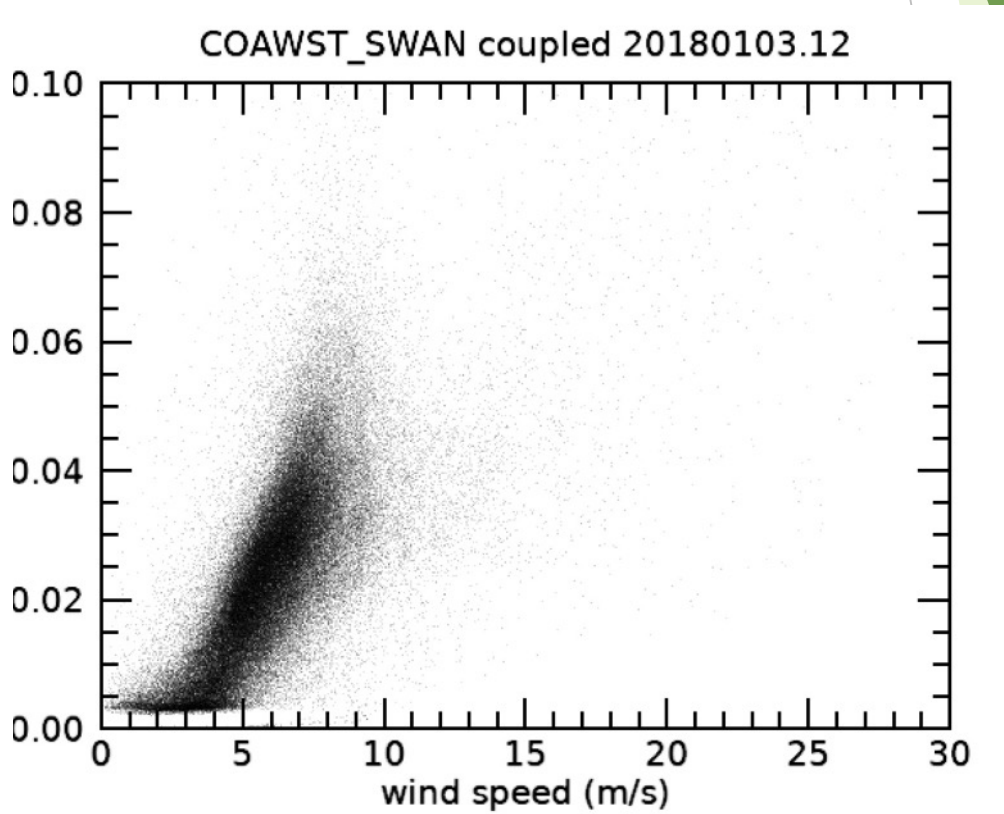
WRF

Mean Square Slope (MSS) comparison between CYGNSS retrieval and SWAN wave model simulation

CYGNSS



SWAN



Conclusions

- The Good:

CYGNSS observed temporal and spatial variations in surface wind and fluxes are consistent with MJO general structures, and compare reasonably well with COAWST model simulations.

- The Bad:

Mean values of CYGNSS retrieved surface fluxes are lower than WRF simulations. This is troublesome because the IMERG observed mean surface rainfall is higher than model simulation;

The MSS vs. wind have different trends for CYGNSS observation and SWAN wave model simulation, especially at higher wind velocities.

- The Ugly:

WRF model needs to be nudged (T and Q) to get good MJO precipitation signals.

We could not make sense of WaveWatch III model coupled in the system work yet.